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METEOROLOGICAL RESEARCH COMMITTEE

Ozone concentration measurements from an aircraft in N. Norway

by
A. W. Brewer (Clarendon Laboratory, Oxford)

Introduction

As a result of a suggestion of D. Tönsberg of the Nordlys Observatoriet at Tromsö, that the Norwegian Air Force would, if suitably approached, provide us with aircraft facilities, a visit was made to N. Norway from April to July of 1955 to make measurements of the vertical distribution of ozone and water vapour. The work was part of a general programme to determine the world wide distribution of ozone and represents an extension of the work of Kay (with Brewer and Dobson) in S. England. (Kay, 1953). The expedition was supported by the Royal Society. There is especial interest in N. Norway because of its high geographical latitude (Tromsö is at 70°N) and the Nordlys Observatory has made a long series of total ozone measurements there, and also "Umkehr" curves, from which some information about the vertical distribution of ozone can be obtained.

Equipment used

The meteorological equipment taken was:-

1. A standard M.O. pattern balanced bridge aircraft air temperature thermometer.

2. An automatic dew-point hygrometer with pressurised test chamber, so that compressed air from the jet engine could be used.

3. The ozone sampler which was used by Kay and was loaned back to us by the Meteorological Research Flight for the expedition. The sampler had been in the possession of the M.R.F. for some time. It had been modified by the M.R.F. for electric instead of mechanical operation; this improvement proved very valuable.

The thermometer and the hygrometer were carried to provide simultaneous data so that the ozone concentration could be correlated with the temperature and humidity structure.

Installation in aircraft

The instruments were installed in a Vampire trainer (two seater) the only suitable aircraft available. The installation, which was made as simple as possible, was completed by R.N.A.F. ground staff in two weeks and in early May the aircraft and crews were moved from Trondheim, where the installation work was done, to Bardufoss near Tromsö for the operational flights.

Early flights

During May four ascents were made to 40,000 feet but after some early doubts it became clear on the fourth ascent that the ozone sampler was not in fact working satisfactorily and that from the ozone point of view these ascents were abortive. Careful tests showed that ozone was being absorbed in the pipes in the sampler leading to the analysing tubes, and on dismantling the apparatus it was found that these were encrusted internally with what appeared to be dried solutions and the products of corrosion of brass and copper. Attempts to clean the apparatus at Bardufoss occupied about two

weeks but failed, and it was decided to return to Trondheim.

At Trondheim, after repeated attempts to get the apparatus to work correctly, it was decided to rebuild all necessary parts of gold, glass or anodised aluminium. Anodised aluminium seemed, on consulting the available literature, to be the most suitable base metal. This took about ten more days. In carrying out this work Professor Westin of the National Technical High School at Trondheim gave substantial assistance.

With these modifications all the tests which could be made at Trondheim suggested that the sampler was now working satisfactorily, and measurements of the ozone concentration made in flight at 1500 feet gave substantially the same value as that obtained near the ground as measured by the techniques tested in the Westmorland experiments described by Kay (1953). The aircraft and men then returned to Bardufoss.

Final flights

Four ascents were then made between 24th June and 12th July. The results of these four ascents are given graphically in Figs. 1, 2, 3 and 4.

It will be seen that except for the ascent of 28.6.55 the ascents show approximately constant concentration (cm./Km. or $\mu g/\rho^3$) up to the tropopause, corresponding to about a 3-1 increase in mixing ratio. On 28.6.55 the concentration approximately doubled between 15,000 feet and the tropopause. All the ascents, but particularly those of the 27th and 28th of June, show a large increase in ozone concentration at the tropopause but the increase is much smaller on 11th July when the ascent was in an air stream of tropical maritime origin.

These results are to be compared with those of Kay (1953), who found that on the average there is no marked change in the ozone concentration at the tropopause. It is possible that this is a real geographical difference or it may be that Kay's results were affected by ozone absorption in the pipes, and this point must be investigated. It is also possible that the accumulation of dirt in the pipes is responsible for the smaller amount of ozone recorded in the stratosphere in the last two flights when compared with the first and second.

The general feature of an increase in ozone concentration at the tropopause is of course a reasonable one and the increase observed is of about the correct amount to account for the observed correlation between total ozone amount and tropopause height. A very variable lower stratosphere concentration would account for the rather low correlation coefficients which are sometimes obtained.

Further work

In view of these results it is very desirable to carry out a considerable amount of further work and it is hoped that this may be possible with the assistance of the Meteorological Office.

1. It is essential that further tests be made with the sampler to ascertain whether the risk of absorption of ozone in the piping is still serious or whether it can be eliminated completely. Fortunately the Vampire used in N. Norway has now been sold to the R.A.F. and arrangements have been made for the aircraft to be available at the M.R.F. for a short time to carry out tests on the actual installation.

2. Sufficient ascents must be made in S. England with a thoroughly tested apparatus to check Kay's results.

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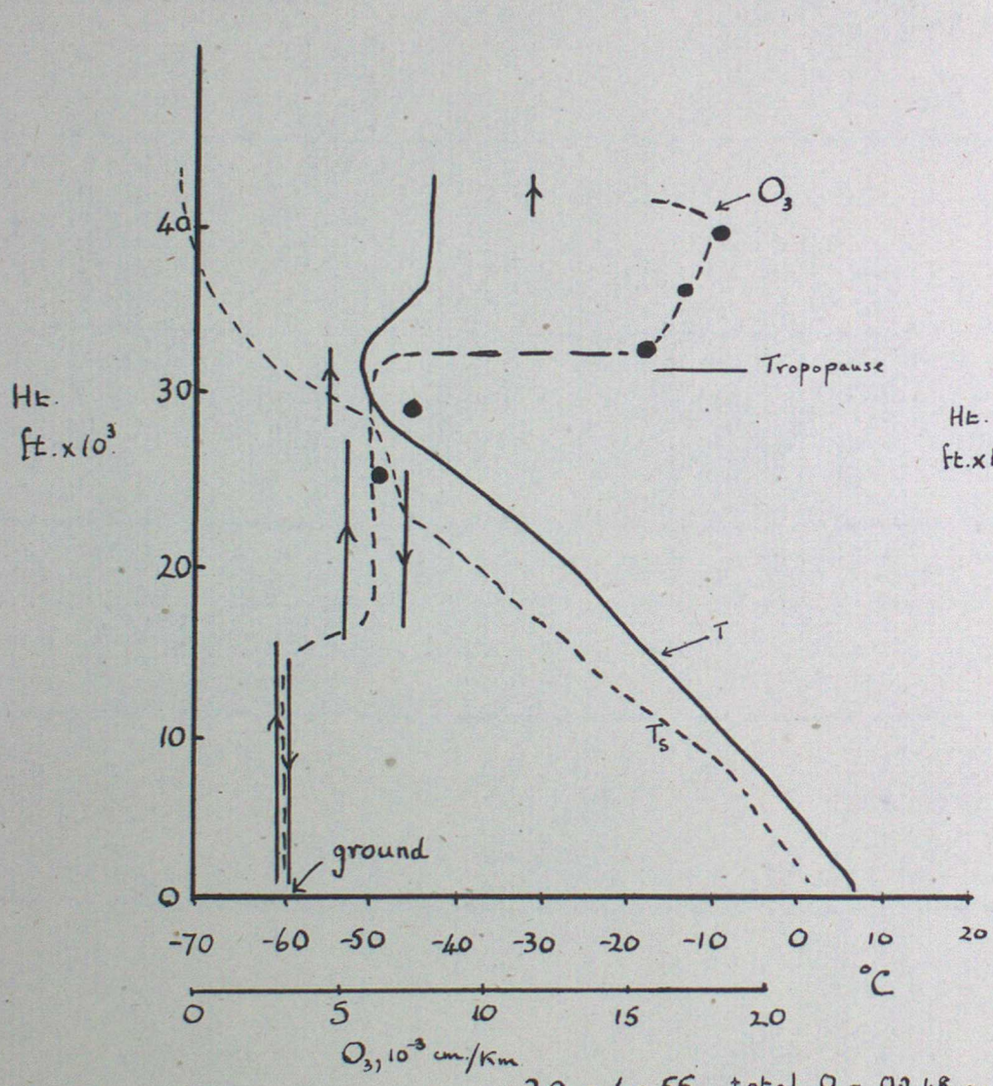
3. If the changes of stratospheric ozone observed in these ascents in N. Norway are real it may be associated with either different air masses or with the annual variation of ozone or both, and it would be most desirable to learn more about the mechanisms involved. Observations in S. England may show something of the former but the annual effect could be best investigated in N. Norway where the total ozone has a large annual variation. In particular during December and January there is a very rapid increase in total ozone, and observations from an aircraft made at that time would show whether the increase is occurring in the lower stratosphere. Simultaneous temperature and humidity measurements would also form a useful investigation of the polar tropopause structure, about which we know so little.

Acknowledgements

The British Council and the British Air Attaché in Oslo made the arrangements for the visit and were most helpful in many ways during the course of the work. The Royal Norwegian Air Force provided the aircraft, carried out all the installation work, and provided all flying facilities, and helped in every way possible. It is a great pleasure to acknowledge the generous assistance which I received in every way and from everyone concerned in the R.N.A.F. It is also a pleasure to acknowledge the help I received from Professor Westin, National Technical High School, Trondheim and from Ing. Gisle Dyvik also of the N.T.H., when I was in difficulties with the sampler. The Gassiot Committee of the Royal Society paid personal travelling expenses.

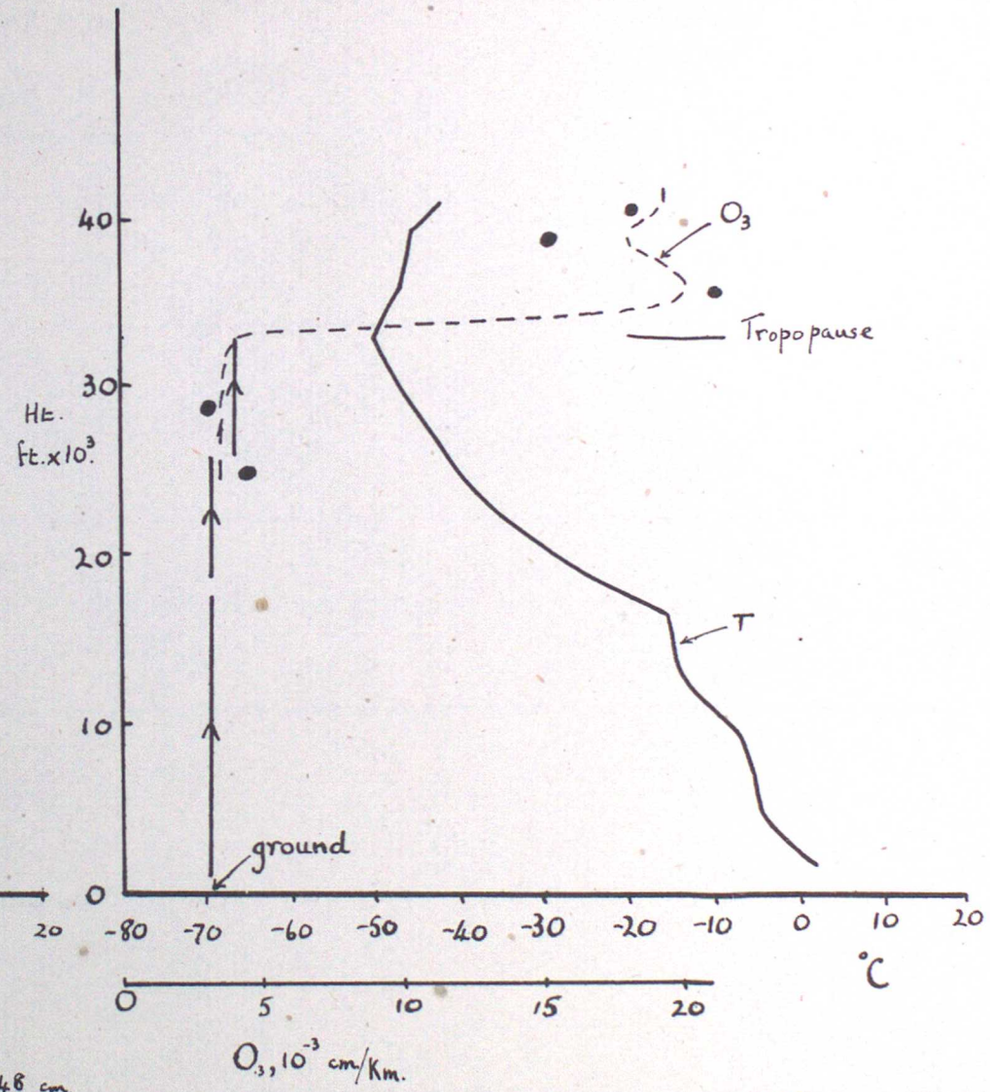
Reference

Kay, R. H. 1953 Meteorological Research Papers, Air Ministry, London. No. 817.



28.-6.-55. total O_3 = 0·248 cm.

Fig. 2.

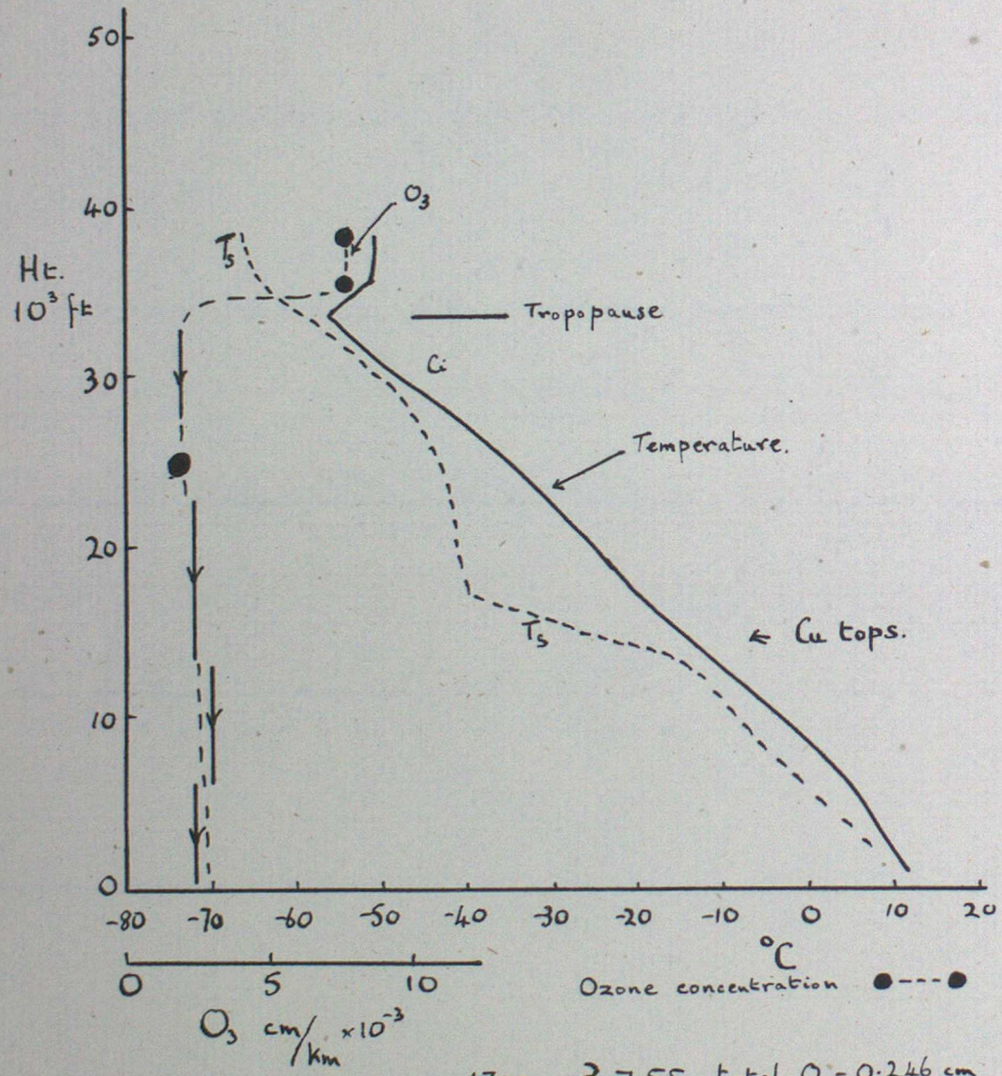


27.6.55. total O_3 = 0·256 cm.

O_3 concentration ●---●

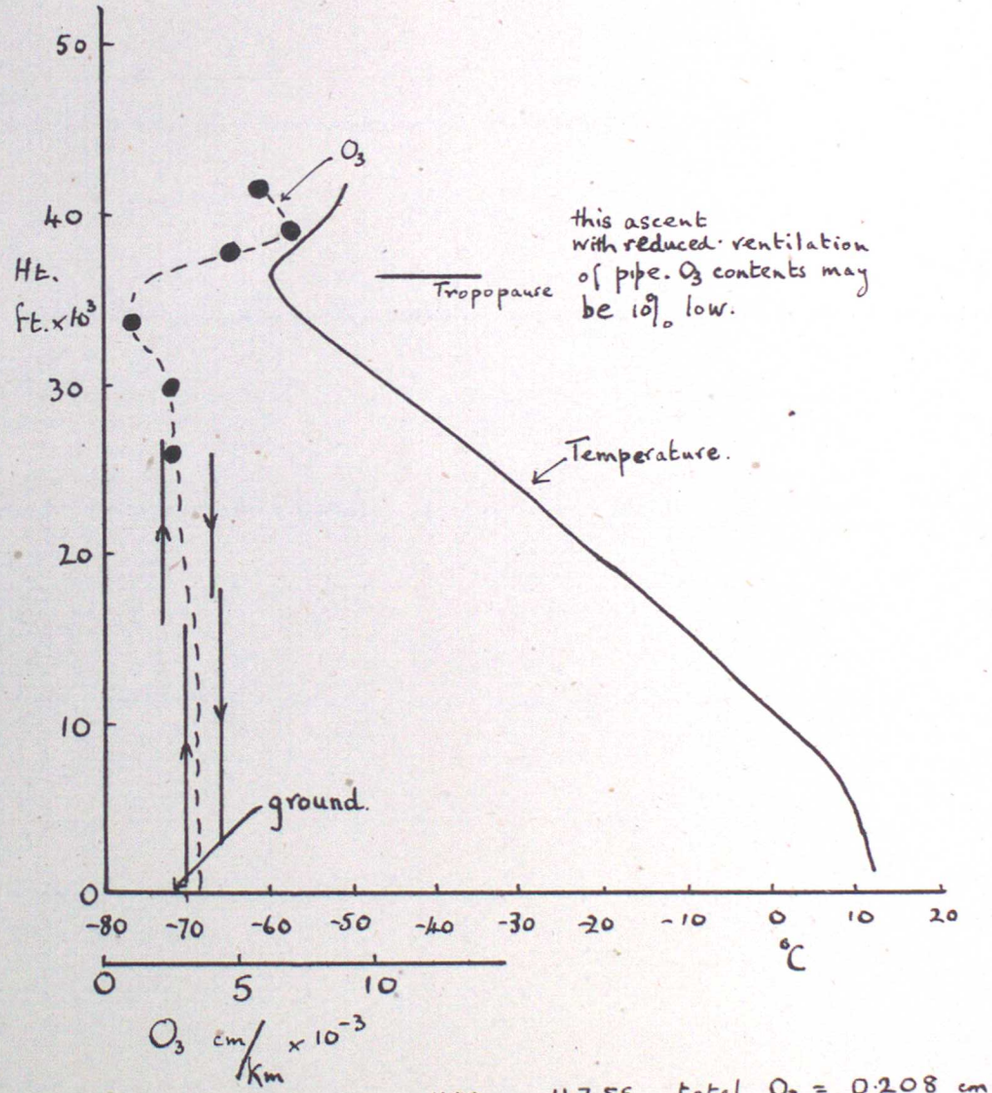
O_3 concentration, measured while climbing or descending ↑ or ↓

Fig. 1.



17.00. 3.7.55, total O_3 = 0·246 cm

Fig. 3.



11.00. 11.7.55. total O_3 = 0·208 cm

Fig. 4.